West Lothian Local Development Plan 27/08/2019
Reference number 107813

# LINLITHGOW MODEL DEVELOPMENT TESTING


West Lothian Council

SYSTRA

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# 1. INTRODUCTION

1.1.1 This note details analysis of various development and network scenarios coded and assigned to the Linlithgow Vissim model. This model was recently updated and recalibrated as detailed in "20190108_Linlithgow_VISSIM_Model_Report.pdf". As such the base model used for the scenario testing has robust representations of the AM and PM peak periods for the 2018 base year.

1.1.2 SYSTRA has developed two basic forecast year scenarios which continue from seven previous scenarios assessed in previous work (using the 2015 version of the Linlithgow Vissim model):

- Scenario 8 – modelling of all LDP housing sites in Linlithgow as set out in Table 1 (proposed housing sites), Table 2 (employment sites) and including the proposed M9 J3 Westbound facing slips.
- Scenario 9 – based on Scenario 8 above but with the addition of the Bo'Ness housing site in Falkirk Council area as listed in Table 3. Trip generation is derived from TRICS and mode choice from 2011 Census for Bo'Ness.

1.1.3 In each case, the maximum development size was used so that the scenarios represented the worst-case traffic impact.

Table 1. West Lothian Local Development Plan – Proposed Housing Sites in Linlithgow

| LDP SITE REFERENCE | LOCATION | SITE SIZE (HA) | CAPACITY (UNITS) |
|---|---|---|---|
| H-LL 1 | 81-87 High Street | 0.3 | 41 |
| H-LL 2 | Westerlea Court, Friarsbrae | 0.3 | 12 |
| H-LL 3 | Boghall East | 3.2 | 50 |
| H-LL 4 | Land east of Manse Road | 1.2 | 25 |
| H-LL 5 | Falkirk Road (land at BSW Timber) | 0.7 | 18 |
| H-LL 7 | Clarendon House, 30 Manse Road | 2.6 | 8 |
| H-LL 11 | Wilcoxholm Farm/Pilgrims Hill | 20.0 | 200 |
| H-LL 12 | Preston Farm | 6.0 | 60 |
| H-LL 13 | Kettlestoun Mains | 14.3 | 210 |

Table 2. West Lothian Local Development Plan – Proposed Employment Sites in Linlithgow

| LDP SITE REF | LOCATION | SITE | SIZE (X100M$^2$) |
|---|---|---|---|
| E-LL 1 | Mill Road Industrial Estate, Linlithgow Bridge | 0.6 | 5 |
| E-LL 2 | Land at Burghmuir, north of Blackness Road | 9.6 | 6 |

Table 3. West Lothian Local Development Plan – Other Proposed Developments in Linlithgow

| COUNCIL SITE REF | LOCATION | CAPACITY (UNITS) |
|---|---|---|
| HO1-LDP1 | Drum Farm | 183 |
| HO2-LDP1 | Kinglass Farm | 160 |
| HO3-LDP1 | Kinglass Farm 2 (Off Drum Rd) | 25 |
| MO1-LDP1 | Boness Foreshore | 750 |
| 102-LDP2 | Crawfield Road | 450 |
| 103-LDP2 | North Bank Farm | 200 |
| 104-LDP2 | Carrieden Brae North, Muirhouses | 120 |
| 105-LDP2 | East Muirhouses | 120 |
| 106-LDP2 | Dunacre Road | 28 |

1.1.4 Note that the M9 J3 Westbound facing slips are based on the latest proposal (provided by WLC) which indicates the use of roundabouts as means of access to the existing road network.

1.1.5 The scenarios detailed above have variants with and without the west facing slips at M9 J3, these have the naming convention 8b and 9b. This naming convention has been chosen to differentiate the above scenarios from previous modelling work.

1.1.6 The methodology is as per previous modelling in test scenarios (1-7) for the M9 J3 west facing slips for those sites that are located in Linlithgow and to the south. For reference, this methodology, extracted from our proposal, is documented below:

- The original model does not contain any traffic interaction on the M9 as it was not part of the original scope. As we will be modelling west facing slips onto the M9, we will not be able to monitor the merge point located on the M9 ramp. In other words, this project cannot measure the impact of any scenario on the operation of the M9; and
- It is our intention to estimate the level of traffic associated with the new the M9 Junction 3 layout by amending the traffic patterns already contained within the development scenarios. A common-sense approach will be undertaken to enable traffic only associated with certain zones to be allowed to use the new junction setup, for example, it is anticipated that development traffic located to the west of

Linlithgow will not route through the town centre to access the westbound on-slips to travel west.

1.1.7 With regards to the Bo'Ness housing sites, SYSTRA have undertaken a more detailed evaluation of the trip distribution using TRICS. The TRICS database provides an indication of typical multi-modal trip rates for residential developments of this nature. These rates are then used to further refine the modal split assumption and to determine locally specific origin / destination patterns.

# 2. DEMAND SCENARIOS

2.1.1 The TRICS database was used to determine the level of car usage associated with the housing locations. Average trip rates were obtained for the AM and PM Peaks as shown in the tables below.

Table 4. Residential trip rates

| PERIOD | MODE | CENSUS MODAL SPLIT PERCENTAGE | TRIP RATE (PER DWELLING) |
|---|---|---|---|
| AM | Car/Van | 67% | 0.848 |
| PM | Car/Van | 67% | 1.013 |

Table 5. Industrial employment trip rates

| PERIOD | MODE | TRIP RATE (PER 100 $M^2$) |
|---|---|---|
| AM | Car/Van | 0.571 |
| PM | Car/Van | 0.438 |

Table 6. Business park employment trip rates

| PERIOD | MODE | TRIP RATE (PER 100 $M^2$) |
|---|---|---|
| AM | Car/Van | 1.247 |
| PM | Car/Van | 0.939 |

2.1.2 The trip pattern of the new development sites is based on an existing trip pattern of a similar area within the model, using the existing zone loading points. Trips from the new development sites are assessed to determine their loading points onto the network and added to the existing model matrices.

2.1.3 Table 6 below provides an indication of the total number of trips loaded onto the network as a result of the development scenarios

Table 7. Development Scenario Traffic Demand.

| PERIOD | MODEL | MATRIX TOTALS (LIGHT VEHS) |
|---|---|---|
| AM | 2017 Base | 3,613 |
| | Base + Full Dev Demand | 6,284 |
| | Base + Full Dev Demand - Bo'Ness | 5,557 |
| | WFS Base Demand + WFS Full Dev Demand | 6,284 |
| | WFS Base Demand + WFS Full Dev Demand – Bo'Ness | 5,557 |
| PM | 2017 Base | 4,252 |
| | Base + Full Dev Demand | 7,357 |
| | Base + Full Dev Demand - Bo'Ness | 6,669 |
| | WFS Base Demand + WFS Full Dev Demand | 7,357 |
| | WFS Base Demand + WFS Full Dev Demand - Bo'Ness | 6,669 |

2.1.4 For the full-development scenario the maximum size of development was used in each case. This included the large Bo'Ness development.

2.1.5 From the scenarios denoted "- Bo'Ness", trips from/to the Bo'Ness development were eliminated. This resulted in 727 fewer trips in the AM period and 688 fewer trips in the PM period.

2.1.6 On the introduction of the West Facing Slips (WFS) at M9 J3 we have assumed that all trips which currently go from the east of Linlithgow to the west (leaving the modelled area on the A803) will now use the WFS. This is illustrated in Figure 1 where the zones within the blue catchment area and going to / from the red circled zone will instead use the WFS (green circle). The WFS are represented by zone 56 (to M9) and zone 57 (from M9).

2.1.7 The change to the demand matrices representing the WFS scenario affects around 90-140 trips in the peak hours (in each direction and including development trips). Effectively, this scenario reroutes upwards of 200 vehicles / hour from Linlithgow High St for the full-development scenario.

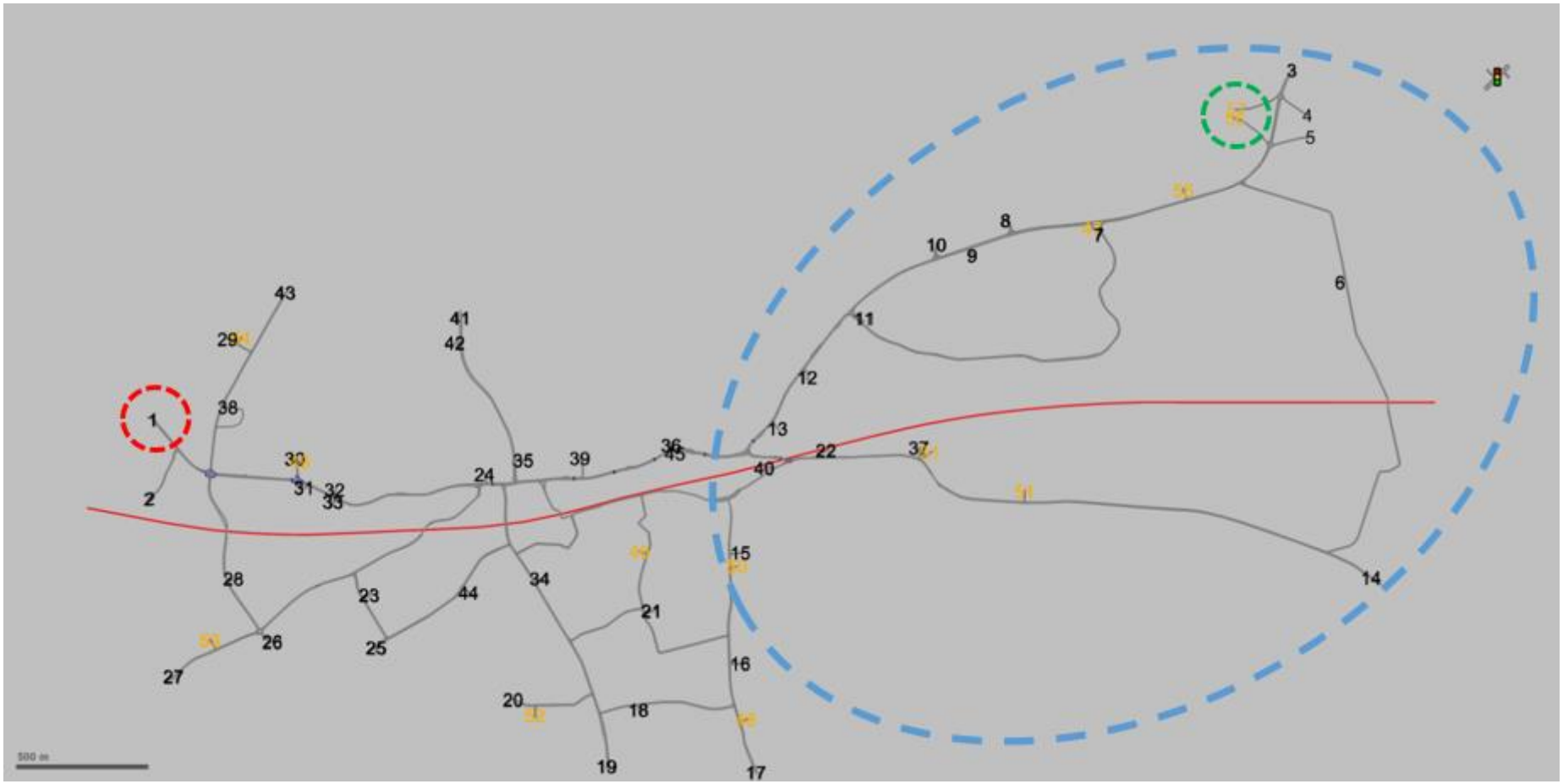


**Figure 1. WFS Demand modification (blue = WFS catchment zones, red = original origin / destination zone, green = new WFS zones)**

# 3. WFS SCHEME LAYOUT

## 3.1 Vissim Network Changes

3.1.1 Figure 2 below shows the M9 J3 West Facing Slips (WFS) proposal received from West Lothian Council in early 2019. The design consists of two new roundabouts which tie in with the existing east facing slips.

3.1.2 Figure 3 shows the equivalent section of the Linlithgow Vissim model with the WFS coded. The M9 itself and the slips' interaction with the M9 are not included in the model.

3.1.3 **SYSTRA have completed a feasibility costing for the proposed WFS.** Please note that what we have completed is an extremely high-level cost estimate, which is based on our recent experience of developing high-level cost estimates for different Grade Separated Junction (GSJ) layout options for a potential GSJ on the Scottish trunk road network. Therefore, once more information is available a more robust cost estimate will require to be undertaken to establish accurate construction costs. The anticipated costs are as follows:

Cost Estimate

- Eastbound diverge and westbound merge: £7.5M
- Roundabouts (x2): £1.0M
- Total: £8.5M

3.1.4 Rather than providing a single cost estimate we believe that it is prudent to provide a cost range. Therefore, please assume that the cost range for construction of the eastbound diverge and westbound merge plus the two roundabouts is **£6.5M to £10.5M**.

Assumptions & Exclusions

- This cost estimate only covers the **construction costs** associated with the junction i.e. other costs such as design costs (inc. costs associated with design work such as the acquisition of a topographical survey, costs associated with a ground investigation, etc.) and site supervision costs are not included;
- No work to the existing overbridge across the M9 or to the existing eastbound merge and westbound diverge are necessary;
- The underlying ground is suitable for construction of the eastbound diverge and westbound merge i.e. there will be no requirement to excavate unsuitable material and replace with suitable backfill material prior to construction of the diverge and merge;
- The presence of any existing Public Utilities apparatus within the footprint of the works is not known at this time and therefore a nominal allowance is included in the above costs, the actual costs could vary significantly from this amount;
- Costs associated with land acquisition have been omitted;
- Costs associated with ecological and environmental mitigation measures have been omitted;

- Any connections to (and amendments to) the existing local road network, properties or farm accesses that may be required as a consequence of the works have not been included in this cost estimate; and
- It has been assumed that suitable drainage outfalls will be available on both sides of the M9 within the proximity of the works.

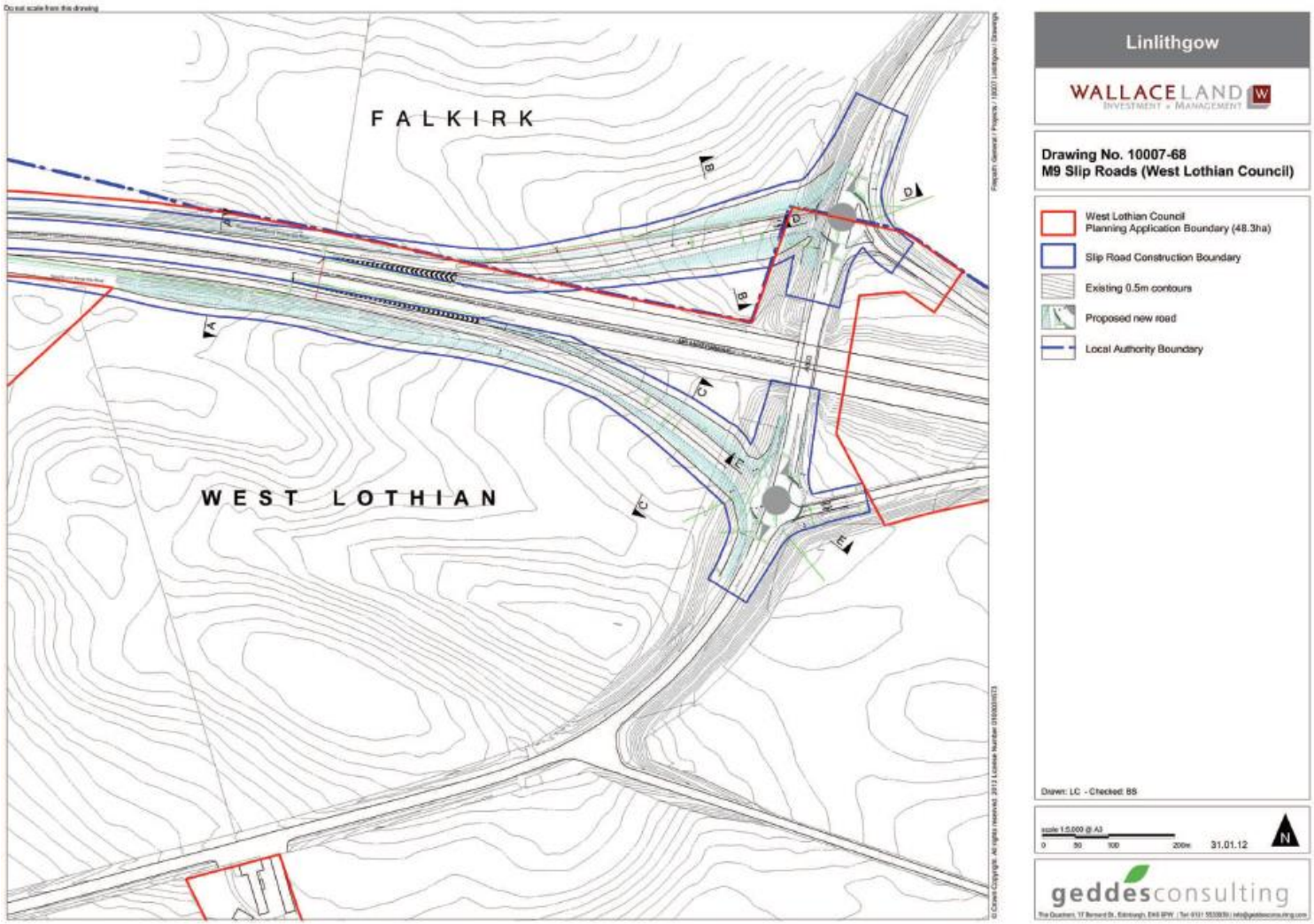


**Figure 2. WFS Plan**


**Figure 3. WFS Network Changes**

# 4. MITIGATION

## 4.1 Blackness Road / High Port / High Street

4.1.1 The existing roundabout at this junction can be the cause of blocking back from the High Port signalised junction as well as from the signalised pedestrian crossing on High St. As such, WLC requested that we evaluate the replacement of this roundabout with a fully signalized junction. An initial evaluation of the space available indicated that two lanes could be accommodated on all approaches. Replacing an existing roundabout with a signalised junction can sometimes lead to increased delay but does allow better balancing of the capacity for various approaches better pedestrian facilities and more reliable journey times.

4.1.2 To enhance the provision for pedestrians at this location (there are currently no zebra or signalised crossings on High Port or High St) and to address the clear pedestrian demand evident during our site-visit, we have coded an all-red traffic phase to allow for a "scramble" pedestrian crossing – i.e. allowing all pedestrian movements at the same time in the signal cycle.

4.1.3 The cycle time of the signals was matched to the existing signals at Back Station Road to allow the most robust vehicle progression through both junctions. The close-by pedestrian crossing on High St was also set to this cycle time to allow better traffic progression westbound along High St. The existing signalised crossing on Blackness Rd was removed.

4.1.4 Reduced speed areas representing the slowing of traffic due to School Crossing Patrol were also removed due to the introduction of signalised crossings.

4.1.5 Figure 4 shows the layout of this junction as coded in the Vissim model.

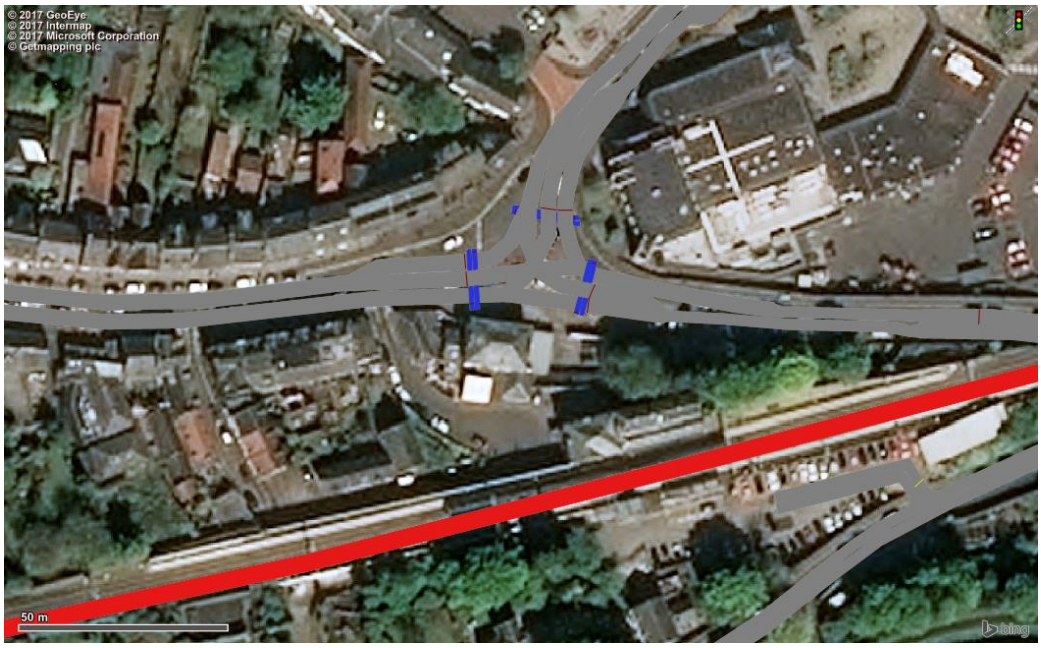


**Figure 4. Blackness Rd signals**

4.1.6 SYSTRA has calculated the approximate cost of the improvements at High St/Blackness Rd/High Port (roundabout to signalised junction) to be **£330k**.

4.1.7 This price is based on the following assumptions:

(a) Surface course replacement over extents of junction (planing off top 40mm and replacing), islands , ped crossing points for all-ways movement, new footways where there are changes to road areas, new bollards, new pedestrian guard-rails.

(b) Based upon no understanding of the presence or location of utilities, we have made no allowances for utilities protection or diversions, which could be significant.

(c) In terms of traffic management during construction, we have merely made allowance via 20% contingencies (we expect there will be high traffic management costs).

(d) Given that the junction is in an urban location and has existing road/footway we have assumed no allowance for earthworks/poor ground.

(e) Drainage allowances made for tying into existing drainage system with new gullies.

## 4.2 St Ninian's Road / High Street

4.2.1 To mitigate the queuing created by the development demand at this location, a mini-roundabout was coded at the junction of St Ninian's Rd / High St. This intervention enables priority to be given to right-turning traffic from St Ninian's and taken from High St westbound.

4.2.2 It was necessary to move the bus stop opposite St Ninian's Rd to the east of the junction to allow for two approach lanes. Keep clear areas were also coded to help prevent traffic queuing through the junction.

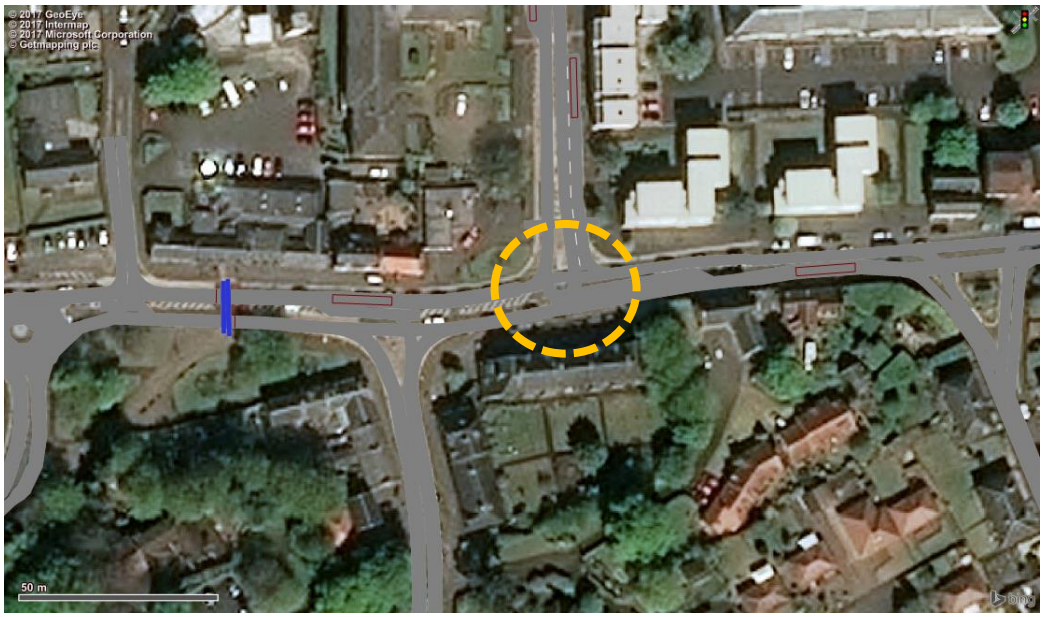


Figure 5. St Ninian's Road mini-roundabout

4.2.3 SYSTRA has calculated the approximate cost of the improvements at St Ninians Rd/High St (priority junction to mini-roundabout) to be **£143k**.

4.2.4 This price is based on the following assumptions:

(a) We have allowed for surface course replacement over the full extents of junction (planing off top 40mm and replacing), new islands, new footways where there are changes to road areas, new bollards, new pedestrian guard-rails.

(b) Based upon no understanding of the presence or location of utilities, we have made no allowances for utilities protection or diversions, which could be significant.

(c) In terms of traffic management during construction, we have merely made allowance via 20% contingencies (we expect there will be high traffic management costs).

(d) Given that the junction is in an urban location and has existing road/footway we have assumed no allowance for earthworks/poor ground.

(e) Drainage allowances made for tying into existing drainage system with new gullies.

## 4.3 Back Station Road / High Port

4.3.1 No physical mitigation is possible at this junction due to the constraints of railway and embankments. Signal green times were however balanced to cope with the increased demand on Back Station Rd westbound.

## 4.4 Mill Rd / Main St

4.4.1 No physical mitigation was considered at this junction. However, signal timings were optimised to balance queues on each approach and better use the full capacity of the existing layout.

# 5. RESULTS SUMMARY

5.1.1 For consistency, we present the same key performance indicators as used in previous studies. Table 4 compares the AM period results of all development scenarios against those of the Base model. Table 5 shows the results for the PM period.

5.1.2 Detailed journey time results for key routes through Linlithgow are presented in Section 5.8.

5.1.3 We have also extracted link vehicle density plots from the models which effectively illustrate the average queue lengths on the network.

## 5.2 Key performance indicators

5.2.1 The various demand scenarios were assigned to the model network to assess their impacts on various key performance indicators. Full network statistics are presented in Table 4 and Table 5. Most indicators are self-explanatory, however descriptions of those that are not can be found below.

5.2.2 **Number of vehicles in the network** – vehicles remaining in the network at the end of the evaluation interval i.e. those vehicles that have started but not completed their trip.

5.2.3 **Number of vehicles that have left the network** – vehicles that have completed their trips at the end of the evaluation interval.

5.2.4 **Demand Latent** – the number of vehicles that haven 't been able to access the network from their zone i.e. when a link is queued back to a zone, vehicles may not be released.

## 5.3 Do Nothing (full development demand no mitigation)

5.3.1 In the AM period, the results show that the impact of the full development traffic on the Base network is an increase in average delay of 14s.

5.3.2 In the PM period, average delay is around a minute higher than the AM period for the equivalent scenario. The Do Nothing scenario results in an increase in average delay of 15s over the Base result.

5.3.3 Figure 6 and Figure 7 show link vehicle density plots for the AM and PM Do Nothing scenarios – key queues are highlighted. These figures show a large increase in queue lengths on St Ninian's Road in both the AM and PM periods. An increase in traffic demand on Back Station Road results in increased queues here in both time periods. Similarly, queues increase in length on Blackness Rd particularly in the PM peak.

5.3.4 At the Main St / Mill Road junction in the PM peak, an increase in demand results in longer eastbound queues.

5.3.5 There is general congestion on High St in both periods.

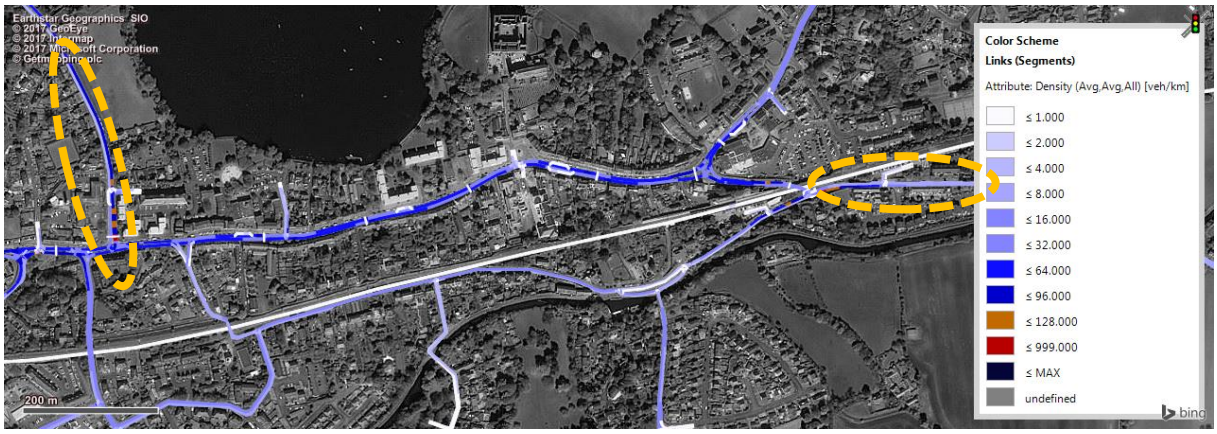


**Figure 6. AM Do Nothing link vehicle density**

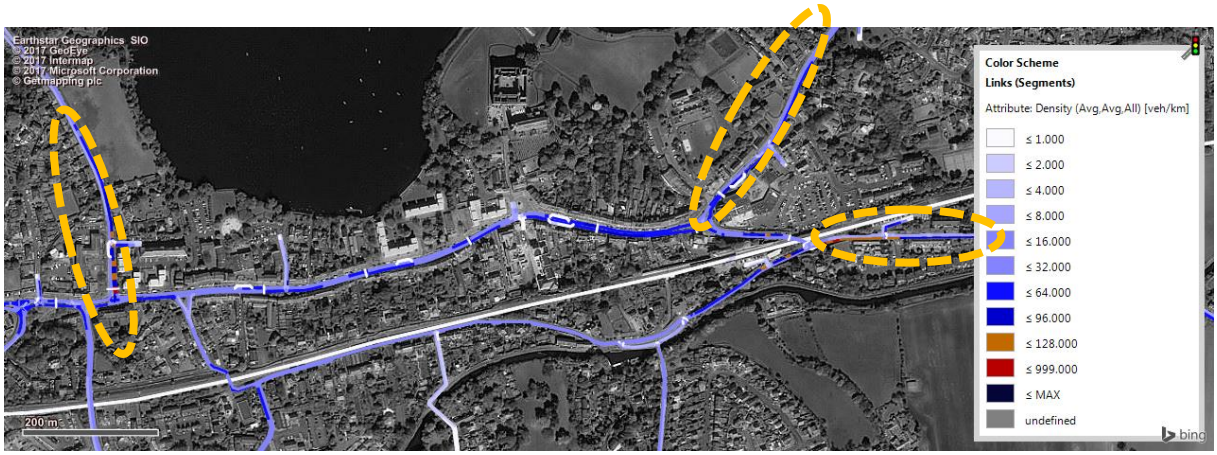


**Figure 7. PM Do Nothing link vehicle density**

## 5.4 Scenario 9a (full development demand WFS)

5.4.1 The introduction of the WFS allows the full development traffic to be accommodated onto the network (9a scenario) with a lower average delay than the Base model. This is because the impact of the WFS is to significantly reduce traffic travelling eastbound through Linlithgow. Some queuing remains on St Ninian's Road however and the Back Station Road and Blackness Rd are also subject to congestion particularly in the PM peak.

5.4.2 Figure 8 and Figure 9 show link vehicle density plots for this scenario with key areas of congestion highlighted.


**Figure 8. AM Scenario 9a link vehicle density**

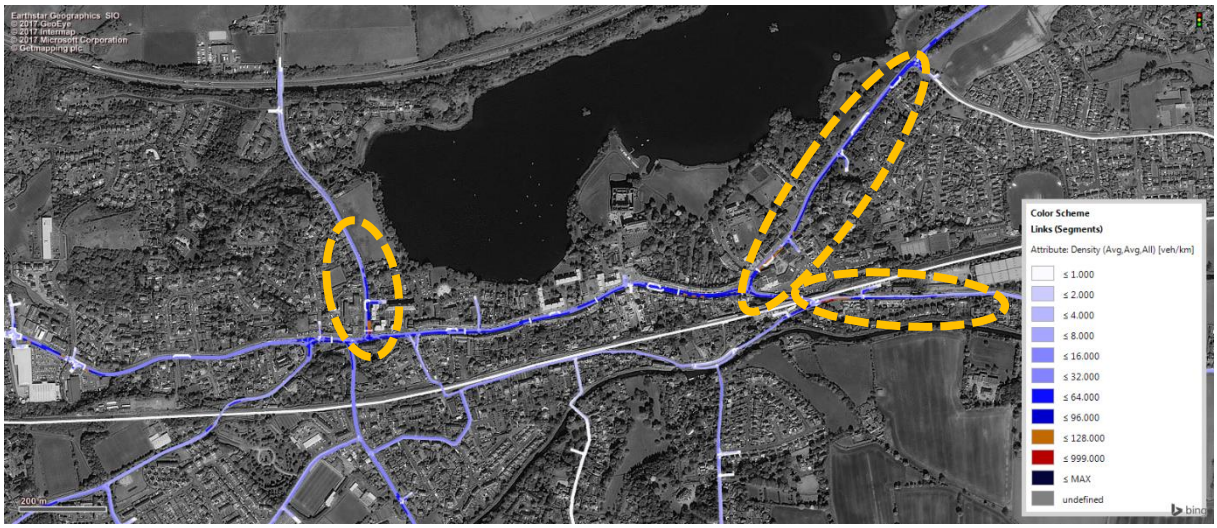


**Figure 9. PM Scenario 9a link vehicle density**

5.4.3 Appendix 1 details the existing and proposed trips that may use the new slips.

## 5.5 Scenario 8a (No Bo'Ness WFS)

5.5.1 Removing the demand associated with the Bo'Ness development slightly improves the network average travel time and average vehicle speeds in the AM peak. Consequently the AM scenario operates with less delay than the Base model.

5.5.2 In the PM peak this scenario has a greater impact, reducing the network average travel times by 17s over Scenario 9a so that the average delay is 132s (the lowest result for any PM scenario) although still much higher than the equivalent AM scenario.

## 5.6 Discussion of unmitigated network results

5.6.1 Analysis of the unmitigated network model results shows that there are several key pinch points on the network that add to delay. The most evident are at St Ninian's Rd, where right turning traffic is unable to access the High St and so forms long queues; and at the High St / Blackness Rd / High Port / Back Station Rd area, where traffic blocks back through the roundabout and causes congestion.

5.6.2 It is however, evident that the impact of the development traffic is significantly reduced when the WFS scheme is introduced. It is also the case that removing traffic associated with development at Bo'Ness also leads to a general improvement in network conditions (and a reduction in the number of "vehicles that have left the network" due to the lower demand associated with this scenario).

5.6.3 Bearing this in mind, and taking cognisance of the network constraints (particularly canal / railway bridges or tunnels) we have therefore tested mitigation measures at St Ninian's Rd / High St (to reduce the very large queues evident here in all scenarios) and at Blackness Rd / High St roundabout (to reduce the incidences of blocking back from the Back Station Rd junction, to improve journey time reliability and to improve pedestrian ambience at this key location).

## 5.7 Discussion of mitigated network results

5.7.1 The proposed network mitigation at St Ninian's Rd resolves the queue at this location caused by development traffic by giving priority to right turning traffic from St Ninian's Rd over westbound traffic on High St. As a consequence of this, more traffic is pushed onto High St's westbound approach to the Mains Rd (A706) roundabout and this section of road quickly reaches capacity. The signalised pedestrian crossing at this location reduces the capacity further leading to blocking back along High St and Preston Rd.

5.7.2 The proposed network mitigation at Blackness Rd / High St / High Port does serve to better manage traffic in terms of keeping this junction clear and provides improved pedestrian facilities. However, the capacity of the junction is not improved over the existing roundabout and so queues, particularly on Blackness Rd, are not generally improved.

5.7.3 Figure 10 shows the AM link vehicle density plot for the Scenario 9b mitigated (Full Development demand). The queue triggered on Preston Rd is highlighted. Figure 11 shows the PM link vehicle density plot for the equivalent PM scenario. The queue on Preston Rd is less severe in this period but queues at Blackness Rd are worse than in the AM.

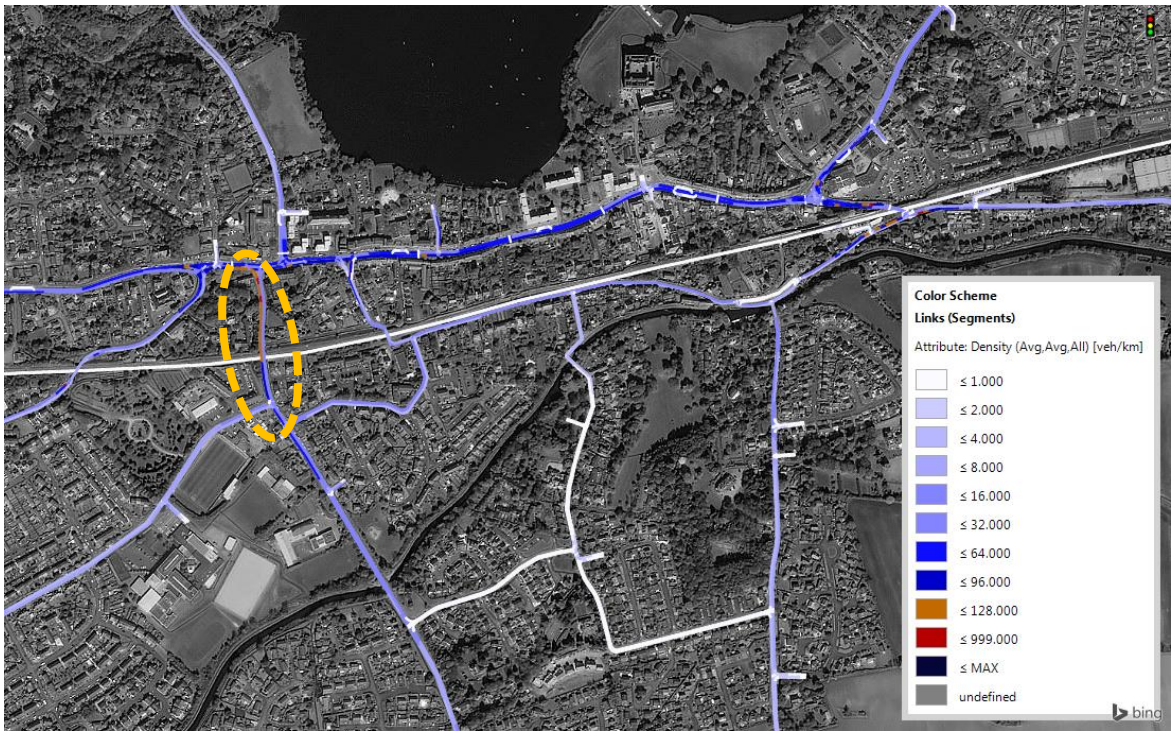


**Figure 10. AM Scenario 9b mitigated**


**Figure 11. PM Scenario 9b mitigated**

5.7.4 Network results show that the mitigated scenarios generally increase average delay over the unmitigated scenarios. This is a consequence of vehicles stopping at a new signalised junction and westbound vehicles on High St losing priority to development traffic on St Ninian's Rd.

5.7.5 The impact of the mitigation on delay in the WFS scenarios is however low. Despite increases in delay over the *unmitigated* Scenario 8a, the *mitigated* Scenario 8a (no

Bo'Ness with WFS) has lower average delay than the Base model in both AM and PM periods.

5.7.6 Scenario 9a mitigated (full development demand and WFS) also has lower delay than the Base model in the PM period.

| MODELS | BASE AM | DO NOTHING AM | 9B MITIGATED AM | 8B MITIGATED AM | 9A AM | 8A AM | 9A MITIGATED AM | 8A MITIGATED AM |
|---|---|---|---|---|---|---|---|---|
| Description | *Base AM* | *Full DevDemand DoNothing* | *Full DevDemand Mitigated* | *NoBoness Mitigated* | *Full Dev Demand WFS* | *NoBoness WFS* | *Full DevDemand WFS Mitigated* | *NoBoness WFS Mitigated* |
| Average delay time per vehicle [s] | 107 | 121 | 172 | 138 | 89 | 82 | 117 | 102 |
| Average number of stops per vehicles | 3 | 4 | 5 | 4 | 2 | 2 | 3 | 3 |
| Average speed [mph] | 16 | 14 | 13 | 15 | 17 | 17 | 16 | 17 |
| Average stopped delay per vehicle [s] | 51 | 58 | 92 | 70 | 41 | 38 | 60 | 52 |
| Total Distance Travelled [km] | 9,098 | 11,142 | 10,903 | 10,156 | 10,897 | 9,997 | 10,750 | 9,951 |
| Total travel time [hrs] | 347 | 451 | 509 | 424 | 409 | 366 | 429 | 375 |
| Total delay time [hrs] | 119 | 168 | 239 | 171 | 124 | 101 | 163 | 126 |
| Number of Stops | 12,381 | 17,795 | 22,997 | 16,253 | 12,308 | 10,118 | 15,853 | 12,359 |
| Total stopped delay [hrs] | 57 | 80 | 128 | 86 | 57 | 46 | 83 | 64 |
| Number of vehicles in the network | 286 | 426 | 509 | 364 | 359 | 319 | 361 | 303 |
| Number of vehicles that have left the network | 3,739 | 4,536 | 4,499 | 4,097 | 4,631 | 4,110 | 4,626 | 4,137 |
| Demand Latent | 0.8 | 0 | 4 | 1 | 0.4 | 0.6 | 0.4 | 0.6 |

**Table 8. Key Performance Indicators AM period**

| SCENARIO | BASE PM | DO NOTHING PM | 9B MITIGATED PM | 8B MITIGATED PM | 9A PM | 8A PM | 9A MITIGATED PM | 8A MITIGATED PM |
|---|---|---|---|---|---|---|---|---|
| Description | *Base PM* | *FullDevDemand DoNothing* | *FullDevDemand Mitigated* | *NoBoness Mitigated* | *FullDevDemand WFS* | *NoBoness WFS* | *FullDevDemand WFS Mitigated* | *NoBoness WFS Mitigated* |
| Average delay time per vehicle [s] | 168 | 183 | 206 | 178 | 149 | 132 | 158 | 149 |
| Average number of stops per vehicles | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 |
| Average speed [mph] | 13 | 12 | 12 | 13 | 14 | 15 | 13 | 14 |
| Average stopped delay per vehicle [s] | 88 | 103 | 111 | 98 | 69 | 59 | 82 | 77 |
| Total Distance Travelled [km] | 10,341 | 12,889 | 12,659 | 12,064 | 12,239 | 11,570 | 12,072 | 11,381 |
| Total travel time [hrs] | 492 | 652 | 661 | 580 | 562 | 494 | 561 | 504 |
| Total delay time [hrs] | 218 | 290 | 327 | 258 | 238 | 191 | 251 | 215 |
| Number of Stops | 21,929 | 26,613 | 29,571 | 23,040 | 24,582 | 19,877 | 23,763 | 19,842 |
| Total stopped delay [hrs] | 114 | 164 | 175 | 142 | 111 | 85 | 130 | 111 |
| Number of vehicles in the network | 549 | 713 | 698 | 566 | 606 | 503 | 629 | 545 |
| Number of vehicles that have left the network | 4,118 | 5,006 | 5,006 | 4,642 | 5,140 | 4,712 | 5,092 | 4,652 |
| Demand Latent | 5 | 67 | 75 | 35 | 6 | 2 | 29 | 21 |

**Table 9. Key Performance Indicators PM period**

## 5.8 Journey Time Analysis

5.8.1 Figure 12 below provides an illustration of the journey time routes used in the analysis. These are the same routes as used in the Base model validation and results are presented for both directions on all routes. Routes are therefore designated NB (northbound), SB (southbound), EB (eastbound), WB (westbound), SW (southwest bound) or NE (northeast bound).

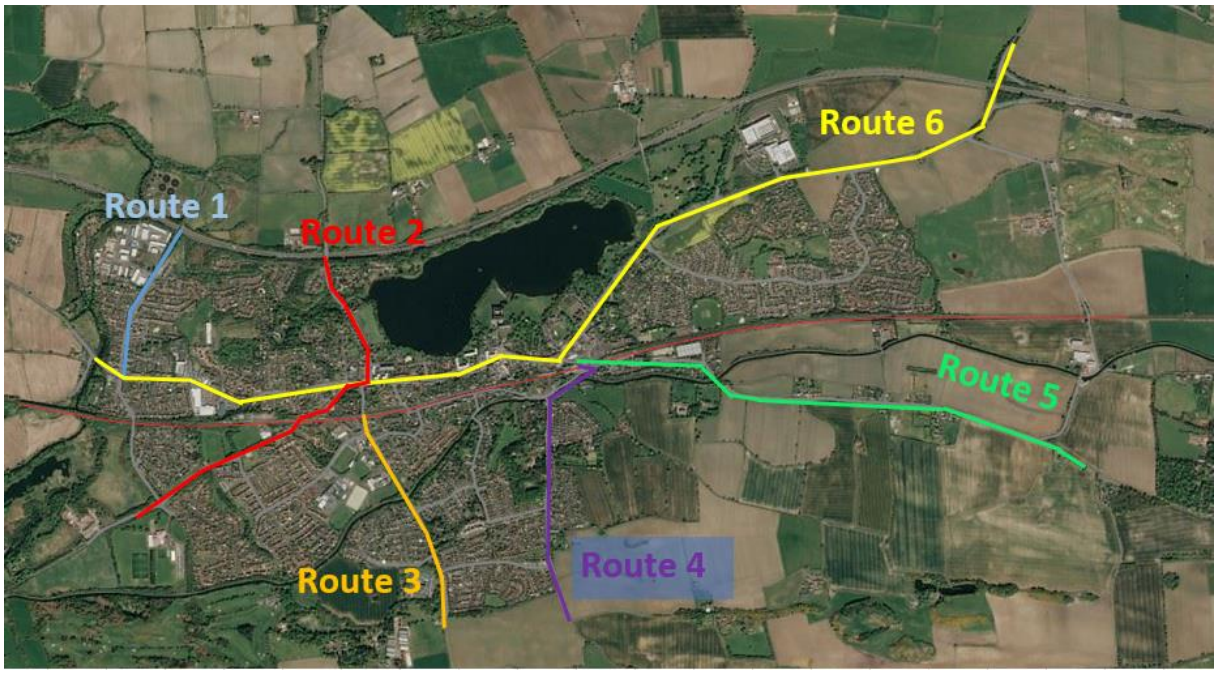


**Figure 12. Journey Times Routes.**

5.8.2 Table 10 (AM) and Table 11 (PM) below show the results for each journey time route for each scenario. The tables are presented as the change of each result from the equivalent Base model result. Results are also colour coded so that red = worse, yellow = no change, and green = better.

5.8.3 **AM Period**

5.8.4 The results for the **Do Nothing** scenario highlight that the largest issue is on St Ninian's Rd southbound where the journey time increases by 319s. This is due to the weight of development traffic using this road and the subsequent lack of capacity at the junction with High St, where right turning vehicles don't have sufficient gaps to make their turn. There are also significant increases on routes 4-NB, 5-WB, 6-SW and 6-NE of 40-70s. These are mostly caused by congestion at the Blackness Rd / High St / High Port roundabout.

5.8.5 Introducing network mitigation (**9b mitigated**) shows that the mini-roundabout at St Ninian's Road / High St substantially improves the travel time on route 2-SB (now just 6s worse than Base result). This is at the expense of travel times on Preston Rd northbound

(route 3-NB) where the weight of the now released development traffic causes 162s of additional delay. Routes 4-NB, 6-SW and 6-NE don't respond well to the introduction of traffic signals at Blackness Rd / High St, all showing additional delay, however route 5-WB does show a modest improvement.

5.8.6 Removing Bo'Ness traffic from the mitigated network (**8b mitigated**) results in substantial improvements to Route 3-NB and Route 6-SW and more modest improvements to Routes 5-WB and 6-NE.

5.8.7 The introduction of the WFS (**9a**) leads to improved results when compared to the Do Nothing scenario. Most journey times are very close to those of the Base model with the exception of Route 5-WB which increases by 75s due to delays approaching town on Back Station Rd.

5.8.8 The mitigated WFS scenarios (**9a mitigated and 8a mitigated**) show a similar pattern of results but with scenario 8a mitigated having several improvements as expected with the reduction of demand. The main change is around the Blackness Rd / High St junction where scenario 8a mitigated has lower journey times due to the signalised junction here now being able to operate within capacity.

5.8.9 **PM Period**

5.8.10 In the PM period, the **Do Nothing** scenario shows large increases in journey times on routes 1-SB, 2-SB and 5-WB. These are caused by the scale of development traffic approaching the High St and Main St on these routes. The improvement in travel time for Route 6-SW is due to reduced delays on the approach to Blackness Rd / High St roundabout and on the section approaching Linlithgow Bridge. In this scenario, the assignment attempts to avoid excessive congestion on the High St by routing eastbound traffic off High St and instead to the south via Royal Terrace. This results in less delay for traffic on Route 6-SW but causes severe delays elsewhere.

5.8.11 As in the AM period, introducing mitigation (**9b mitigated**) shows that the mini-roundabout at St Ninian's Road / High St substantially improves the travel time on route 2-SB (now running faster than the Base model). Preston Rd northbound (route 3-NB) shows a modest 27s of additional delay as a result of the extra development traffic now able to access the High St. Routes 5-WB, 6-SW and 6-NE don't respond well to the introduction of traffic signals at Blackness Rd / High St, all showing substantial additional delay. The travel time increase on route 1-SB is successfully mitigated by the optimisation of traffic signals at the Mill Rd / Main St junction.

5.8.12 Removing Bo'Ness traffic from the mitigated network (**8b mitigated**) results in substantial improvements to Routes 5-WB and 6-SW. The signalised junction at Blackness Rd / High St now operates better leading to lower delay (rather than over capacity as in the Do Nothing).

5.8.13 As in the AM period, the introduction of the WFS (**9a**) leads to improved results compared to the Do Nothing scenario. Some routes are, however, still subject to substantial increases in delay (2-SB, 5-WB, 6-SW at +60s or more over the Base result).

5.8.14 Removing the Bo'Ness development from the WFS scenario (**8a**) has a very positive impact on delays in the PM period. The majority of routes in this scenario are faster than the Base with only route 5-WB slower.

5.8.15 As in the AM period, the mitigated WFS scenarios (**9a mitigated and 8a mitigated**) show a similar pattern of results but Scenario 8a mitigated shows substantial improvements on route 6 in both directions. Scenario 8a does have a modest increase in travel time on route 3-NB on Preston Rd.

| Route | Route Description | Distance (m) | Do Nothing (secs) AM | | 9b mitigated AM Full Dev Demand Mitigated (secs) | | 8b mitigated AM Dev Demand No Boness Mitigated (secs) | | 9a AM Full Dev Demand WFS(secs) | | 8a AM Dev Demand No Boness WFS (secs) | | 9a mitigated AM ALL DEMAND WFS Mitigated (secs) | | 8a mitigated AM No Boness WFS Mitigated (secs) | | 20.Full Dev Demand WFS Preston RT (secs) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-NB | Mill Road/Main | 718.2 | 0% | 0.0 | -1% | -0.4 | 0% | -0.2 | 1% | 0.6 | 1% | 0.5 | 1% | 0.4 | 0% | 0.1 | 1% | 0.3 |
| 1-SB | Mill Road (M9 | 716.52 | 9% | 8.4 | 7% | 6.2 | 8% | 7.6 | 17% | 15.7 | 17% | 14.9 | 5% | 4.1 | 4% | 4.0 | 6% | 5.3 |
| 2-NB | A706 / Kettlestoun | 1897.84 | 7% | 15.8 | 15% | 33.7 | 12% | 27.0 | 0% | -0.6 | -3% | -6.0 | 8% | 18.0 | 4% | 9.2 | 2% | 3.6 |
| 2-SB | St Ninian's Rd (M9 | 1897.79 | 128% | 319.2 | 3% | 6.3 | -5% | -13.4 | 5% | 13.5 | -5% | -13.2 | -7% | -16.6 | -9% | -23.0 | 26% | 63.6 |
| 3-NB | Preston Road -> | 880.2 | -1% | -1.0 | 109% | 162.0 | 8% | 11.4 | -4% | -5.7 | -4% | -6.2 | 33% | 49.6 | 0% | 0.7 | -4% | -6.3 |
| 3-SB | Railway Bridge -> | 880.2 | 0% | 0.6 | 1% | 1.2 | 0% | 0.4 | 1% | 1.6 | 1% | 0.8 | 1% | 0.9 | 0% | 0.2 | 1% | 1.0 |
| 4-NB | Manse Rd -> High | 1186.54 | 37% | 67.7 | 62% | 113.3 | 60% | 108.4 | 3% | 4.6 | 2% | 2.9 | 55% | 100.0 | 33% | 60.6 | 5% | 9.9 |
| 4-SB | High Port -> Manse | 1195.32 | 4% | 6.9 | 11% | 17.7 | 5% | 7.7 | 2% | 2.6 | 3% | 5.4 | 10% | 14.8 | 5% | 7.5 | 2% | 3.7 |
| 5-EB | High Port -> B9080 | 2313.16 | -1% | -2.8 | -1% | -1.5 | -1% | -2.6 | -1% | -2.5 | -2% | -4.2 | -2% | -3.7 | -2% | -4.0 | -2% | -3.3 |
| 5-WB | B9080 -> High Port | 2311.93 | 17% | 38.5 | 10% | 23.0 | 15% | 33.3 | 33% | 75.0 | 26% | 58.0 | 29% | 65.8 | 11% | 25.3 | 34% | 75.1 |
| 6-SW | A803 / Springfield | 4939.27 | 8% | 51.0 | 30% | 186.3 | 5% | 29.0 | 0% | -0.6 | -7% | -46.3 | 7% | 46.0 | -2% | -12.7 | 2% | 12.1 |
| 6-NE | Linlithgow Bridge -> | 4913.89 | 8% | 46.9 | 15% | 91.7 | 14% | 88.7 | 3% | 21.1 | 1% | 3.8 | 6% | 38.3 | 2% | 15.0 | 5% | 29.5 |
| **Total** | | 23850.86 | 19% | **551.0** | 22% | **639.5** | 10% | **297.1** | 4% | **125.2** | 0% | **10.5** | 11% | **317.6** | 3% | **82.8** | 7% | **194.6** |
| **Average Speed (mph)** | | | -16% | | -18% | | -9% | | -4% | | 0% | | -10% | | -3% | | -6% | |

Table 10. AM Journey time summary with respect to the Base model

| Route | Route Description | Distance (m) | Do Nothing (secs) PM | | 9b mitigated PM Full Dev Demand Mitigated(secs) | | 8b mitigated PM Dev Demand No Boness Mitigated (secs) | | 9a PM Full Dev Demand WFS (secs) | | 8a PM Dev Demand No Boness WFS (secs) | | 9a mitigated PM ALL DEMAND WFS Mitigated (secs) | | 8a mitigated PM No Boness WFS Mitigated (secs) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-NB | Mill Road/Main | 718 | 1% | 1.4 | 0% | 0.3 | 0% | 0.1 | 0% | -0.1 | 0% | 0.2 | 0% | -0.1 | 0% | 0.0 |
| 1-SB | Mill Road (M9 | 717 | 257% | 329.0 | 31% | 40.0 | 19% | 24.5 | 8% | 10.8 | 5% | 6.5 | -3% | -3.6 | -6% | -7.4 |
| 2-NB | A706 / Kettlestoun | 1,898 | 5% | 11.2 | 17% | 38.6 | 11% | 24.6 | 3% | 7.8 | 2% | 4.5 | 6% | 13.9 | 4% | 8.6 |
| 2-SB | St Ninian's Rd (M9 | 1,898 | 57% | 200.4 | -26% | -91.9 | -28% | -99.5 | 29% | 100.3 | -18% | -63.9 | -27% | -93.7 | -29% | -102.3 |
| 3-NB | Preston Road -> | 880 | 1% | 1.3 | 17% | 27.1 | 3% | 4.3 | 4% | 6.4 | 2% | 3.0 | 40% | 61.6 | 67% | 103.8 |
| 3-SB | Railway Bridge -> | 880 | 6% | 8.8 | 0% | 0.7 | 1% | 0.9 | 4% | 5.9 | 4% | 5.9 | 0% | 0.1 | 0% | 0.7 |
| 4-NB | Manse Rd -> High | 1,187 | 11% | 24.0 | 10% | 22.3 | -13% | -27.8 | 4% | 9.0 | -11% | -24.4 | 34% | 74.6 | 30% | 67.0 |
| 4-SB | High Port -> Manse | 1,195 | 4% | 6.3 | 13% | 22.0 | 14% | 23.8 | 2% | 2.5 | 0% | 0.4 | 13% | 21.5 | 10% | 16.9 |
| 5-EB | High Port -> B9080 | 2,313 | -1% | -2.5 | -5% | -10.2 | -6% | -12.0 | -1% | -1.6 | -1% | -1.4 | -3% | -6.2 | -3% | -7.0 |
| 5-WB | B9080 -> High Port | 2,312 | 36% | 97.5 | 20% | 54.1 | 2% | 6.4 | 20% | 53.9 | 14% | 38.4 | 3% | 7.0 | 1% | 2.9 |
| 6-SW | A803 / Springfield | 5,016 | -16% | -135.6 | 19% | 161.8 | 3% | 29.9 | 7% | 60.8 | -4% | -37.2 | 7% | 61.0 | -5% | -47.1 |
| 6-NE | Linlithgow Bridge - | 4,915 | 0% | -0.1 | 11% | 74.2 | 7% | 43.7 | 2% | 14.3 | -2% | -14.6 | 3% | 20.5 | -2% | -16.0 |
| | **Total** | **23,929** | 15% | **541.5** | 10% | **339.1** | 1% | **18.9** | 8% | **269.9** | -2% | **-82.7** | 4% | **156.6** | 1% | **20.1** |
| | **Average Speed (mph)** | | -13% | | -9% | | -1% | | -7% | | 2% | | -4% | | -1% | |

**Table 11. PM Journey time summary with respect to the Base model**

# 6. CONCLUSION

6.1.1 This note has provided details of the methodology used to assess various development and mitigation scenarios for Linlithgow using the Linlithgow Vissim Model (2018 base year).

6.1.2 Forecast matrices were developed from LDP housing and employment information for Linlithgow as well as from information for sites in Falkirk Council area (Bo'Ness). The effect of the proposed M9 J3 West Facing Slips was also modelled by amending trip origins / destinations for a catchment area towards the east of Linlithgow.

6.1.3 Several network mitigation measures were coded in response to issues evident in the Do Nothing scenarios. These included a mini-roundabout at St Ninian's Rd / High St, a signalised junction at Blackness Rd / High St / High Port and signal optimisation at various other junctions.

6.1.4 The results of the modelling showed that the impact of development traffic on the Base network will be substantial with higher average delays on the network as a whole. Some individual routes through Linlithgow are severely affected, in particular St Ninian's Rd southbound and all routes using the Blackness Rd / High St / High Port junction.

6.1.5 The proposed network mitigation on its own doesn't allow the level of delay in the network to return to the same level as in the Base. The network mitigation does however allow the long queues on St Ninian's Rd southbound to dramatically improve. However, this tends to have a knock-on impact to delays on High St and Preston Rd. The roundabout at the junction of High St / Mains Rd becomes a pinch-point (especially as capacity is further constrained by the signalised pedestrian crossing to the east). Further improving the capacity of this area may prove difficult given the competing traffic flows in peak hour traffic and the offset nature of the junctions.

6.1.6 The proposed WFS has the effect of removing a substantial amount of traffic from High St, therefore the scenarios including WFS show improvements in network performance over the Do Nothing scenario. These improvements are further enhanced when Bo'Ness development traffic is also removed from the network.

# Appendix 1

**New Development zones using the west facing slips M9J3 (AM peak)**

| Vissim Zones | Description | To WFS | | From WFS | |
|---|---|---|---|---|---|
| | | AM Light Vehicles | AM Heavy Vehicles | AM Light Vehicles | AM Heavy Vehicles |
| 47 | Boghall East | 3 | 0 | 1 | 0 |
| 50 | Claredon House 30 Manse Road | 0 | 0 | 0 | 0 |
| 51 | Wilcoxholm Farm / Pilgrims Hill | 12 | 0 | 3 | 0 |
| 55 | Land at Burghmuir, North of Blackness Road | 2 | 0 | 3 | 0 |
| | **Total** | **17** | **0** | **7** | **0** |

**New Development zones using the west facing slips M9J3 (PM peak)**

| Vissim Zones | Description | To WFS | | From WFS | |
|---|---|---|---|---|---|
| | | PM Light Vehicles | PM Heavy Vehicles | PM Light Vehicles | PM Heavy Vehicles |
| 47 | Boghall East | 2 | 0 | 4 | 0 |
| 50 | Claredon House 30 Manse Road | 0 | 0 | 0 | 0 |
| 51 | Wilcoxholm Farm / Pilgrims Hill | 8 | 0 | 14 | 0 |
| 55 | Land at Burghmuir, North of Blackness Road | 10 | 0 | 2 | 0 |
| | **Total** | **20** | **0** | **20** | **0** |

Development Vissim zones above will be directly impacted by the introduction of the WFS. The trips that these zones were previously generating towards A803 west (Vissim zone 1) are now using the WFS zone instead (Vissim zones 56 out of the Network, and 57 into the Network). The total number of development trips relocated are 24 in the AM peak and 40 in the PM peak.

**Existing Zones using the new west facing slips M9J3 (AM)**

| Vissim Zones | Description | To WFS | | From WFS | |
|---|---|---|---|---|---|
| | | AM Light Vehicles | AM Heavy Vehicles | AM Light Vehicles | AM Heavy Vehicles |
| 3 | A803 to/from Bo'ness | 4 | 0 | 13 | 0 |
| 4 | East Facing on-Slip road | 0 | 0 | 8 | 0 |
| 5 | East Facing off-Slip road | 2 | 1 | 0 | 0 |
| 6 | Kingsfield Golf & Leisure | 3 | 0 | 0 | 0 |
| 7 | Springfield Road | 8 | 0 | 3 | 0 |
| 8 | Oracle Campus | 3 | 0 | 10 | 0 |
| 9 | Grange View | 3 | 0 | 3 | 0 |
| 10 | Oracle Campus | 6 | 0 | 10 | 0 |
| 11 | Springfield Road | 11 | 0 | 3 | 0 |
| 12 | Barons Hill Avenue | 10 | 0 | 3 | 0 |
| 13 | Regent Centre | 10 | 0 | 11 | 0 |
| 14 | B9080 | 17 | 4 | 10 | 3 |
| 15 | Clarendon Road | 6 | 0 | 2 | 0 |
| 22 | Linlithgow Station Parking East | 4 | 0 | 2 | 0 |
| 37 | Edinburgh Road | 6 | 0 | 0 | 0 |
| 40 | Linlithgow Station Parking West | 2 | 0 | 2 | 0 |
| | **Total** | **95** | **5** | **80** | **3** |

**Existing Zones using the new west facing slips M9J3 (PM)**

| Vissim Zones | Description | To WFS | | From WFS | |
|---|---|---|---|---|---|
| | | PM Light Vehicles | PM Heavy Vehicles | PM Light Vehicles | PM Heavy Vehicles |
| 3 | A803 to/from Bo'ness | 8 | 0 | 23 | 0 |
| 4 | East Facing on-Slip road | 0 | 0 | 7 | 0 |
| 5 | East Facing off-Slip road | 8 | 1 | 0 | 0 |
| 6 | Kingsfield Golf & Leisure | 4 | 0 | 0 | 0 |
| 7 | Springfield Road | 6 | 0 | 5 | 0 |
| 8 | Oracle Campus | 2 | 0 | 15 | 0 |
| 9 | Grange View | 2 | 0 | 5 | 0 |
| 10 | Oracle Campus | 4 | 0 | 15 | 0 |
| 11 | Springfield Road | 8 | 0 | 5 | 0 |
| 12 | Barons Hill Avenue | 6 | 0 | 4 | 0 |
| 13 | Regent Centre | 7 | 0 | 11 | 0 |
| 14 | B9080 | 10 | 3 | 19 | 0 |
| 15 | Clarendon Road | 3 | 0 | 1 | 0 |
| 22 | Linlithgow Station Parking East | 4 | 0 | 5 | 0 |
| 37 | Edinburgh Road | 16 | 0 | 0 | 0 |
| 40 | Linlithgow Station Parking West | 4 | 0 | 5 | 0 |
| | **Total** | **92** | **4** | **120** | **0** |

The existing trips above that were previously using the main street towards A803 west (Vissim zone 1) are now using the WFS instead (Vissim zones 56 out of the Network, and 57 into the Network), this includes trips to / from Bo'ness.

The methodology employed did not result in the generation of trips between the new Bo'ness housing allocation sites and the WFS. This is because no new trips for the housing sites were generated to / from Zone 1. Therefore no new trips were reallocated to the WFS.

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**Birmingham – Newhall Street**
5th Floor, Lancaster House, Newhall St,
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T: +44 (0)121 393 4841

**Birmingham – Edmund Gardens**
1 Edmund Gardens, 121 Edmund Street,
Birmingham B3 2HJ
T: +44 (0)121 393 4841

**Dublin**
2nd Floor, Riverview House, 21-23 City Quay
Dublin 2,Ireland
T: +353 (0) 1 566 2028

**Edinburgh – Thistle Street**
Prospect House, 5 Thistle Street, Edinburgh EH2 1DF
United Kingdom
T: +44 (0)131 460 1847

**Glasgow – St Vincent St**
Seventh Floor, 124 St Vincent Street
Glasgow G2 5HF United Kingdom
T: +44 (0)141 468 4205

**Leeds**
100 Wellington Street, Leeds, LS1 1BA
T: +44 (0)113 360 4842

**Liverpool**
5th Floor, Horton House, Exchange Flags, Liverpool,
United Kingdom, L2 3PF
T: +44 (0)151 607 2278

**London**
3rd Floor, 5 Old Bailey, London EC4M 7BA United Kingdom
T: +44 (0)20 3855 0079

**Manchester – 16th Floor, City Tower**
16th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 504 5026

**Newcastle**
Floor B, South Corridor, Milburn House, Dean Street, Newcastle, NE1 1LE
United Kingdom
T: +44 (0)191 249 3816

**Perth**
13 Rose Terrace, Perth PH1 5HA
T: +44 (0)131 460 1847

**Reading**
Soane Point, 6-8 Market Place, Reading,
Berkshire, RG1 2EG
T: +44 (0)118 206 0220

**Woking**
Dukes Court, Duke Street
Woking, Surrey GU21 5BH United Kingdom
T: +44 (0)1483 357705

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